Overview of Central California Winter PM2.5 Data Analysis and Modeling + Issues

[Attainment Demonstration Uncertainty Stemming From Poor Meteorological Model Performance]

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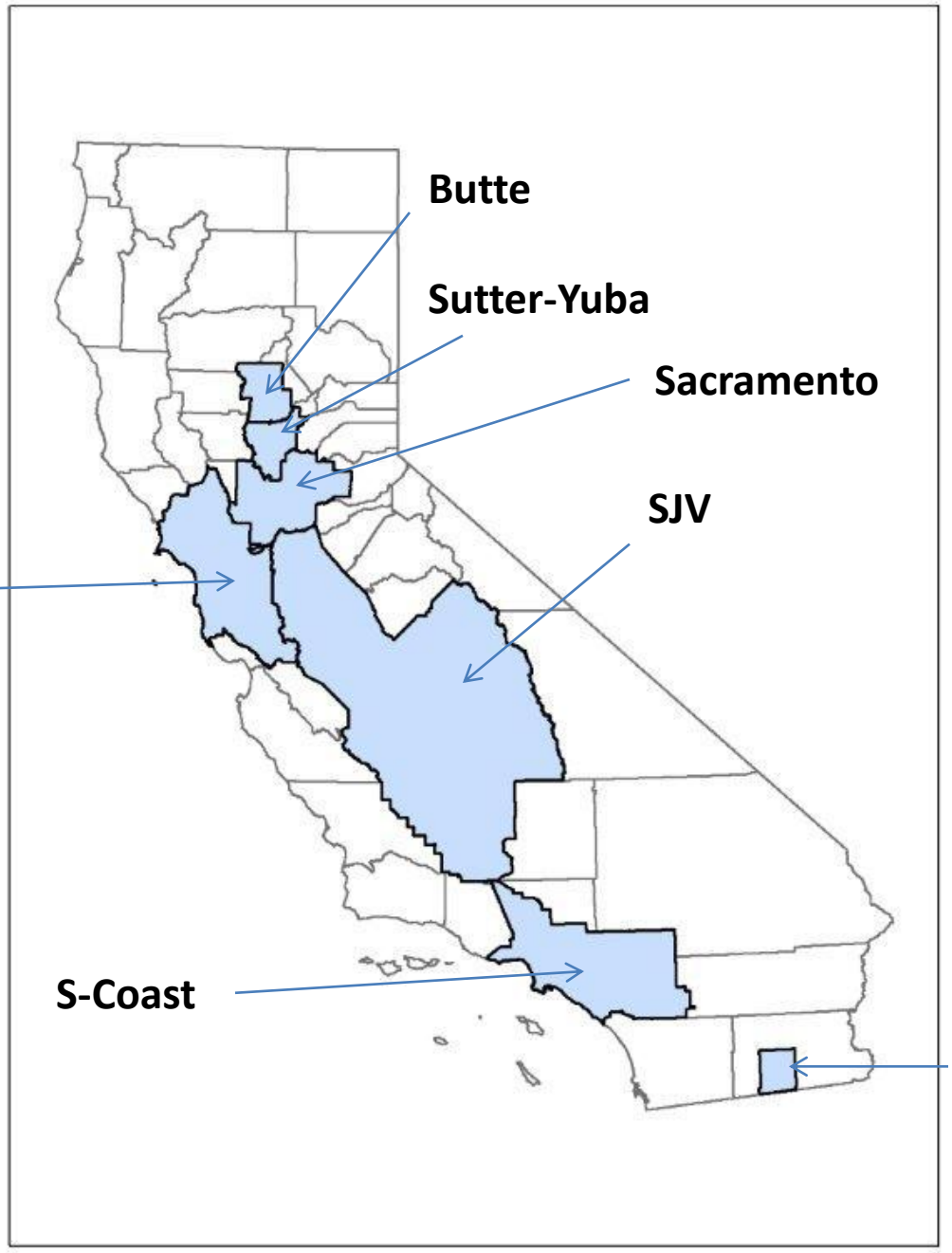
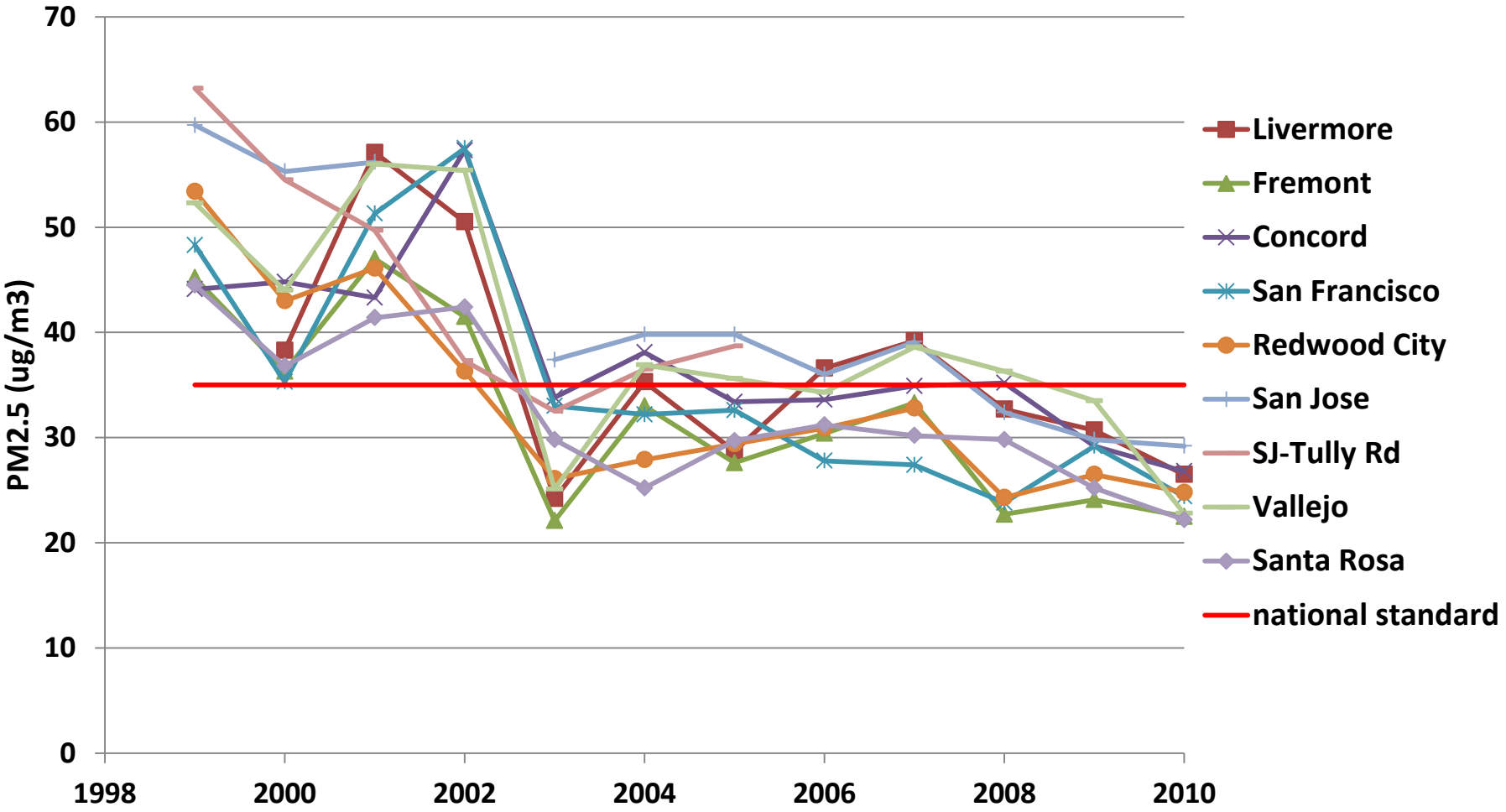
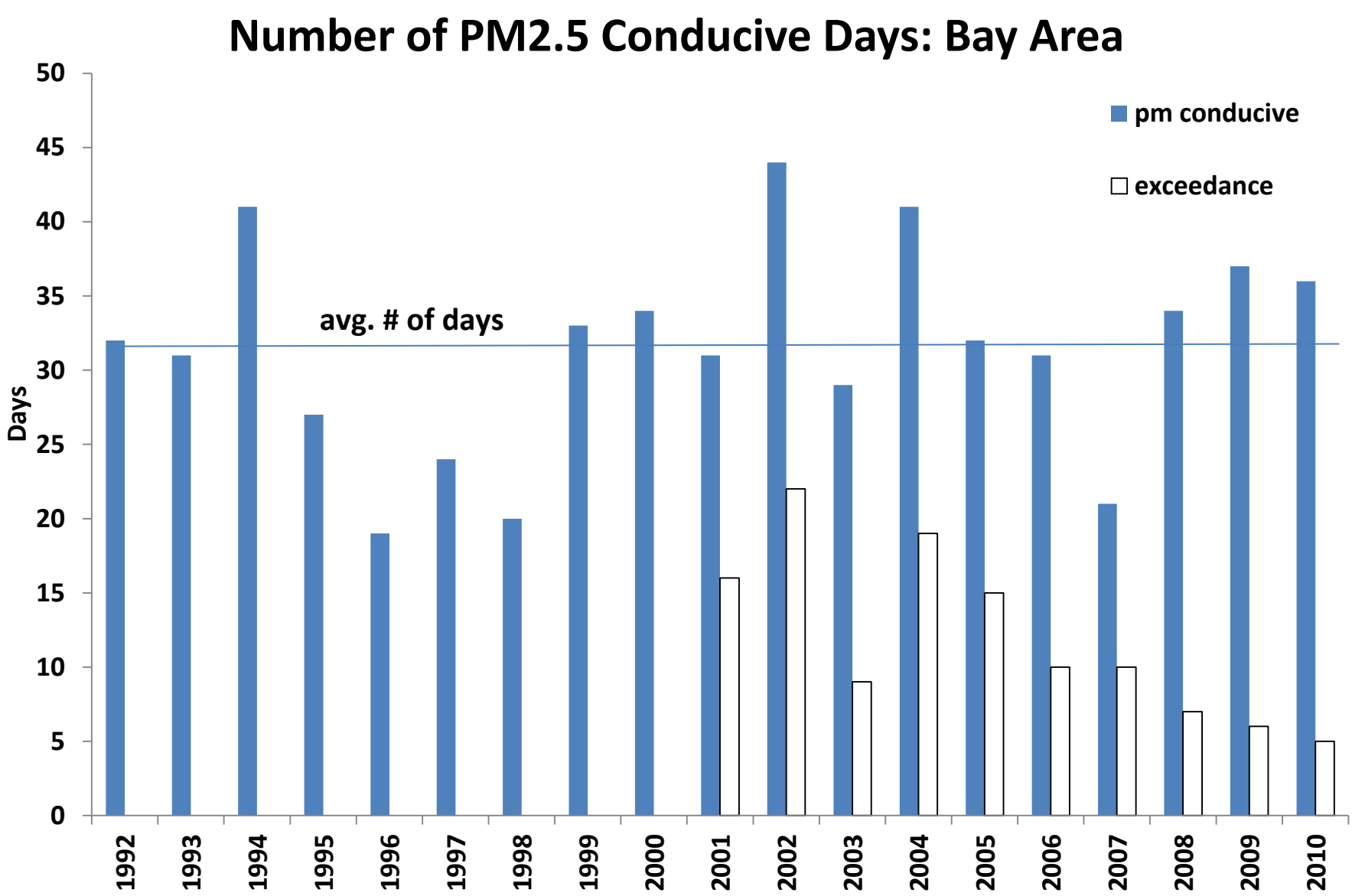
California 24-h PM2.5 non-attainment areas



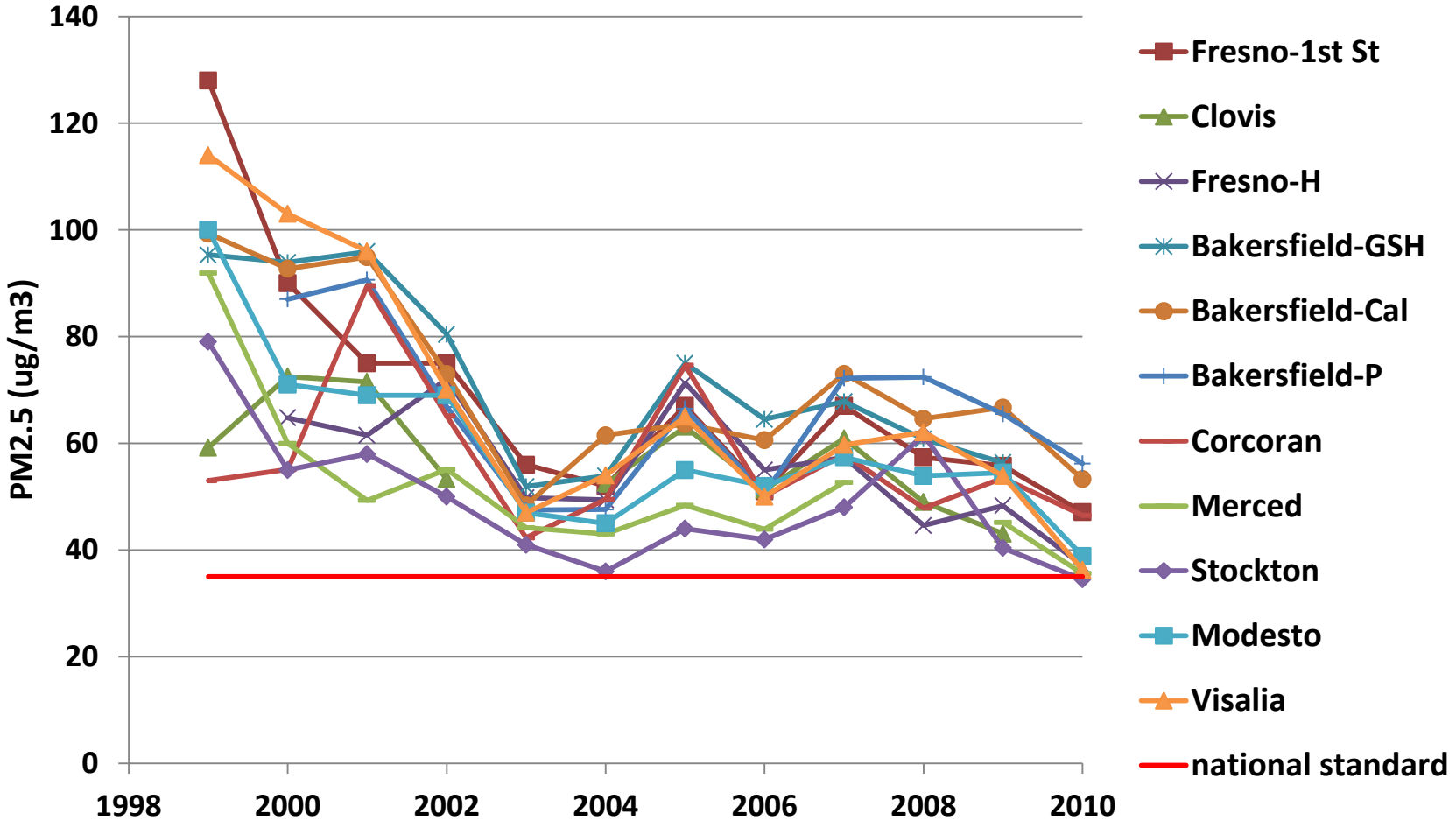
SJV and S-Coast also Exceed Annual Avg. PM2.5 Standard

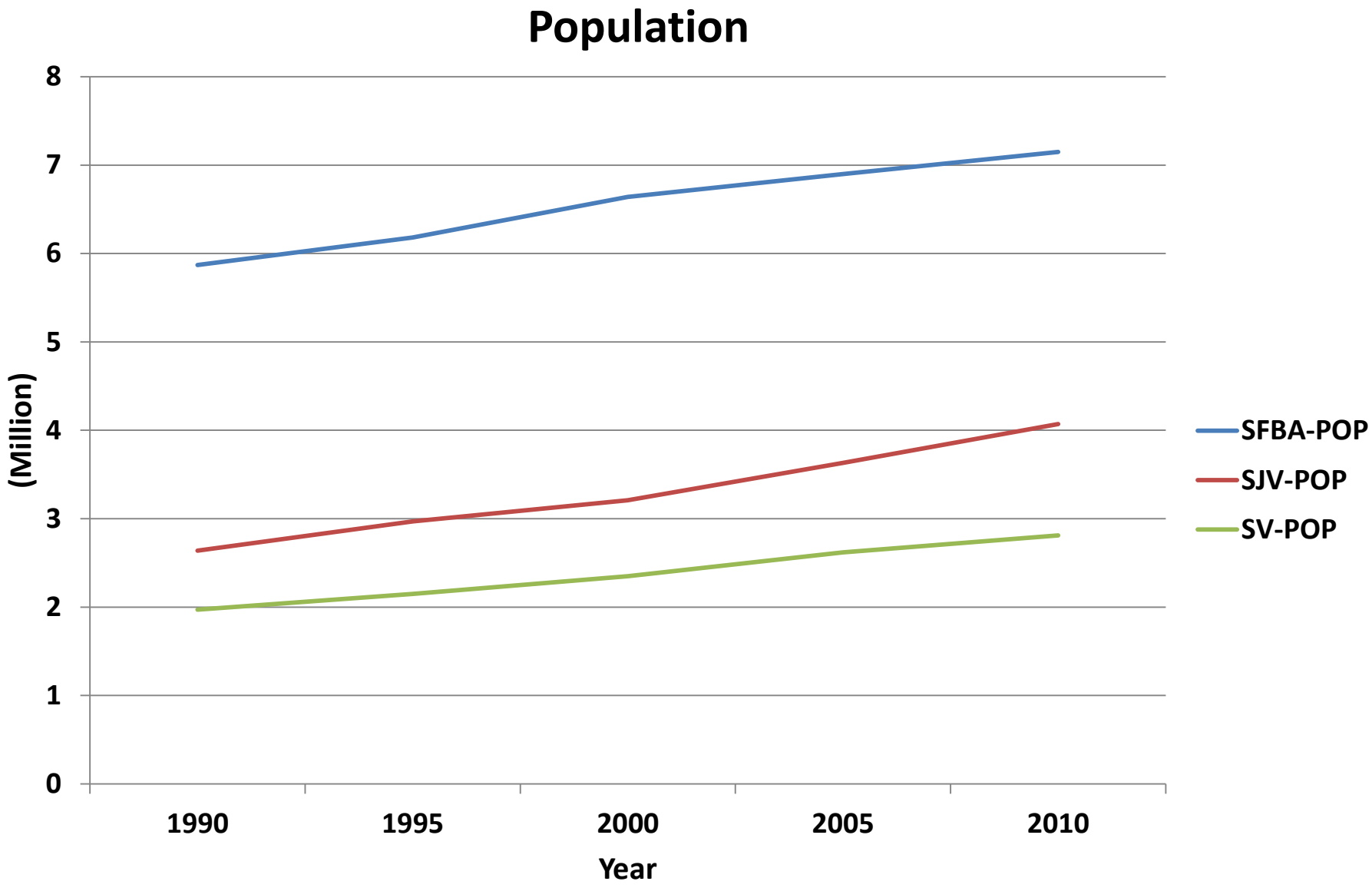
24-h PM2.5 98th Percentiles: Bay Area

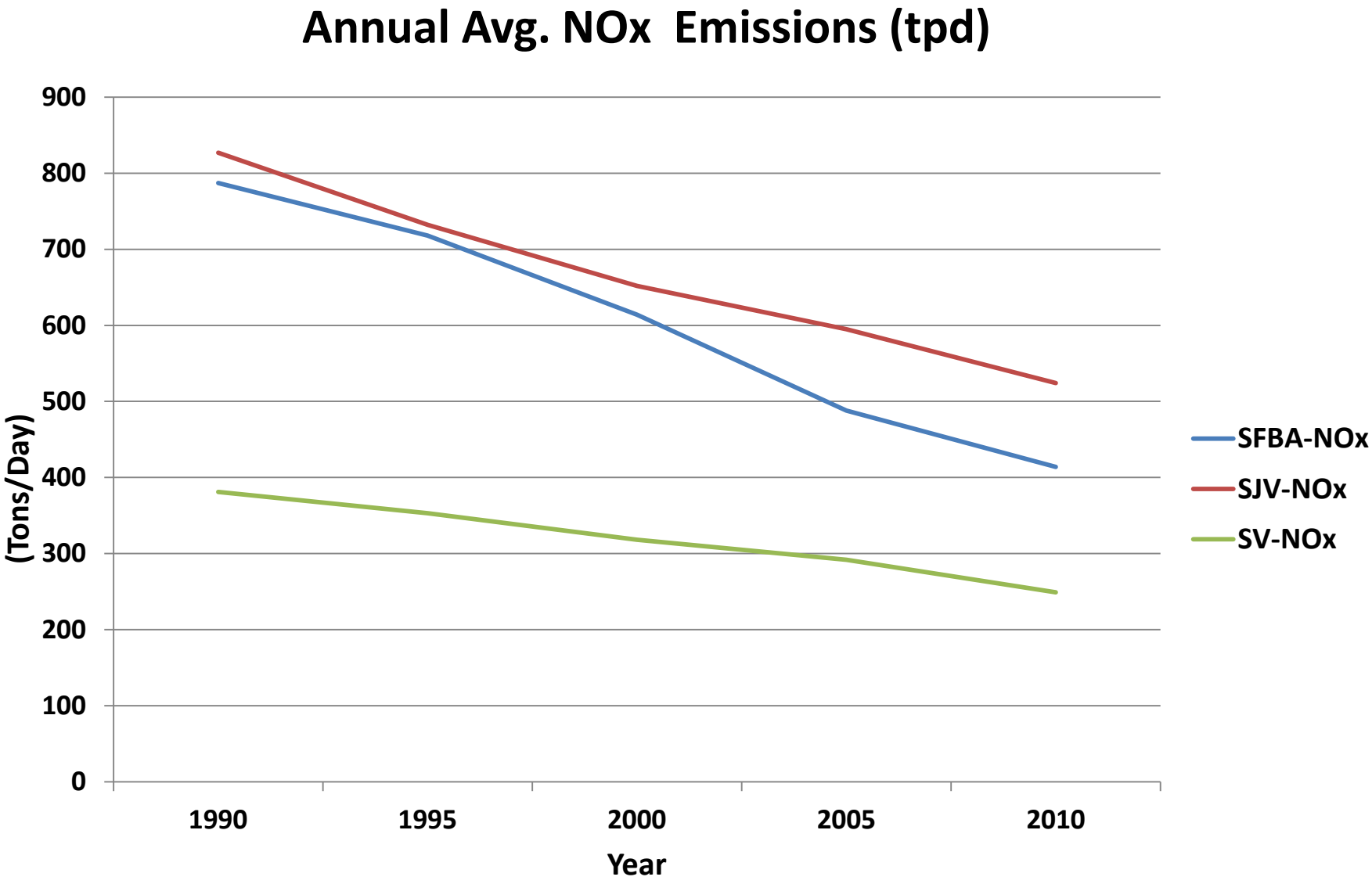



Number of PM2.5 Conducive Days: Bay Area
pm conducive
exceedance
avg. # of days
Days
50
45
40
35
30
25
20
15
10
5
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

24-h PM2.5 98th Percentiles: San Joaquin Valley




Population
8
7
6
5
4
3
2
1
0
(Million)
1990
1995
2000
2005
2010
Year
SFBA-POP
SJV-POP
SV-POP


Annual Avg. NOx Emissions (tpd)
900
800
700
600
500
400
300
200
100
0
(Tons/Day)
1990
1995
2000
2005
2010
Year
SFBA-NOx
SJV-NOx
SV-NOx

Central California PM2.5 Studies

- 1995 IMS
  - Preparation for CRPAQS
- CRPAQS
  - Supplemental measurements (1999-2001)
  - Intensive measurements (December 2000-January 2001)
  - Data analysis
  - Emissions inventory development
  - Modeling
  - Oversight by Technical and Policy Committees
- Additional information
  - http://www.arb.ca.gov/airways (CRPAQS)
  - http://www.baaqmd.gov/Divisions/Planning-and-Research/Research-and-Modeling.aspx (BAAQMD activities)

Data Analysis (BAAQMD)

- Meteorological analysis
  - Meteorological conditions impacting PM2.5
    - Winds and temperatures (surface and aloft)
    - Rain and fog
    - Synoptic conditions and atmospheric stability
    - Cluster analysis (PM conduciveness)
- Air quality analysis
  - Chemical speciation (primary vs. secondary PM2.5)
  - Chemical Mass Balance (Source apportionment)
  - Trend analysis
  - C-14 PM filter analysis to quantify ambient new carbon concentrations (wood burning and cooking)

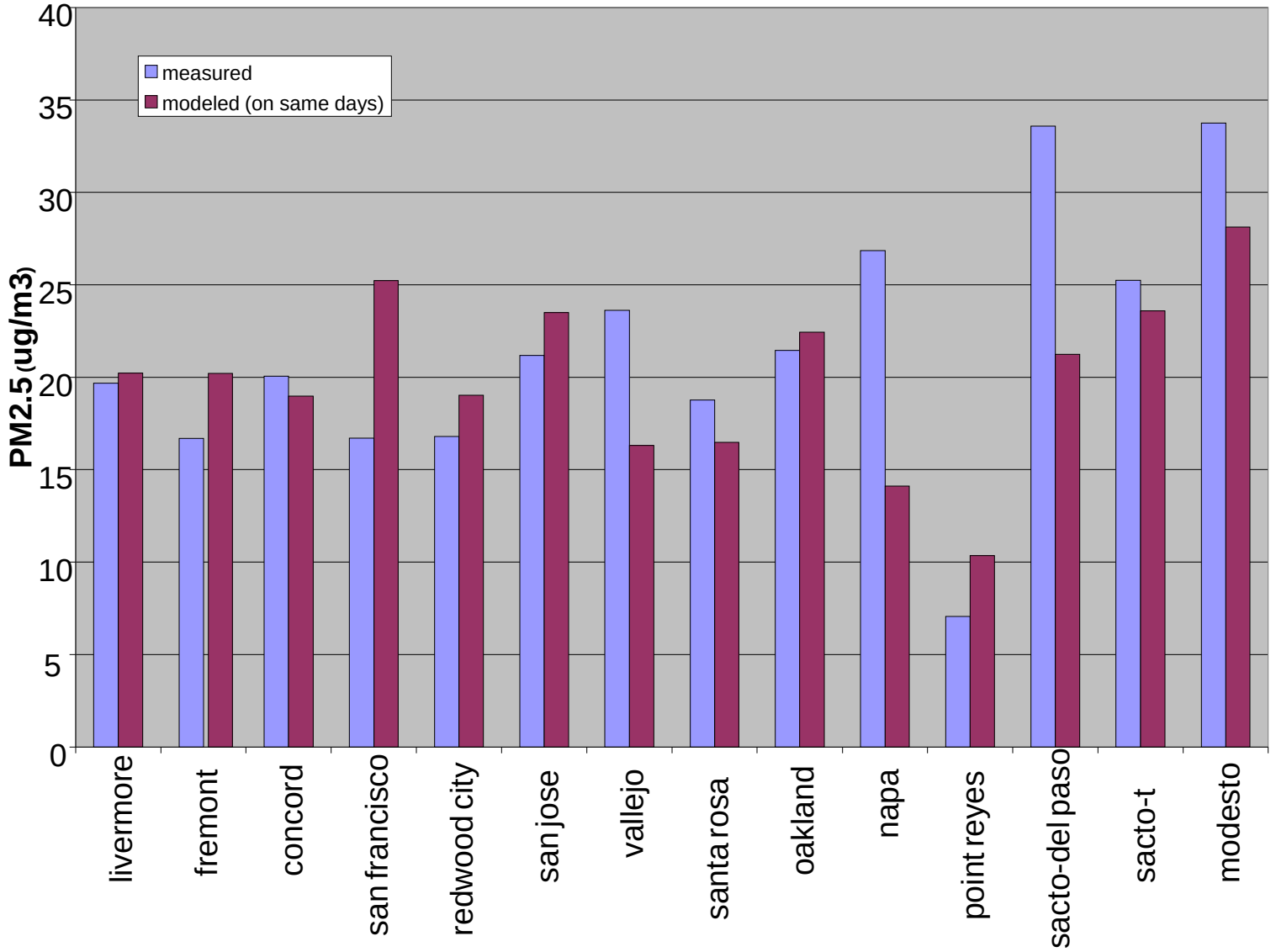
Modeling

BAAQMD modeling - similar to ARB-CRPAQS modeling

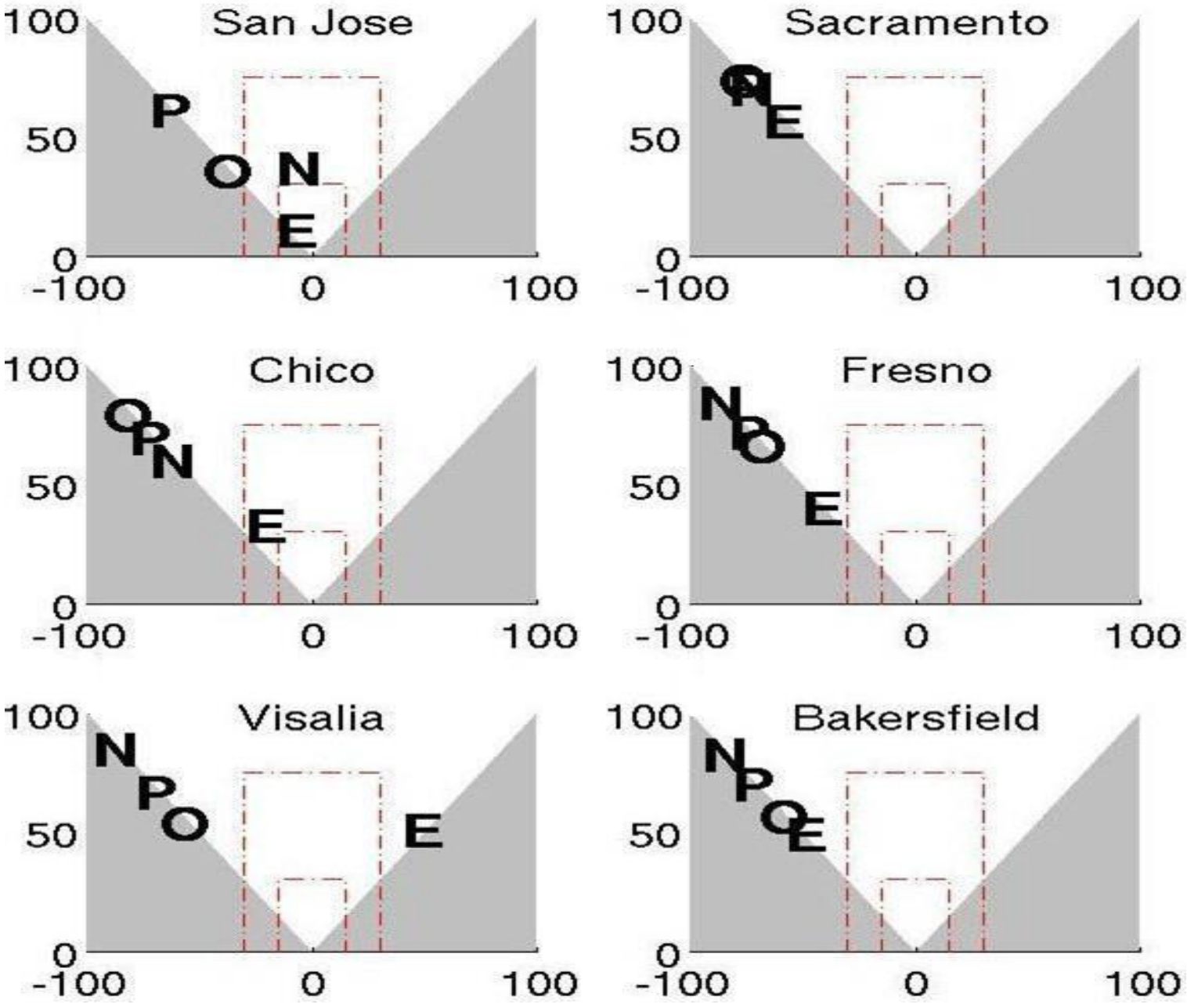
- Meteorological modeling
  - MM5 and WRF
  - 36, 12 and 4km horizontal resolutions
  - 30 or 50 vertical layers
- Air quality model
  - CMAQ (AE4 chemistry) and CAMx (wood burning PM2.5)
  - 4km horizontal resolution (covering central California)
  - 15 or 25 vertical layers
  - SAPRC99-AE4 chemical mechanism (CMAQ)
  - Simulation periods: Dec-Jan, 2000-01 and 2006-07

Simulated vs Observed PM2.5

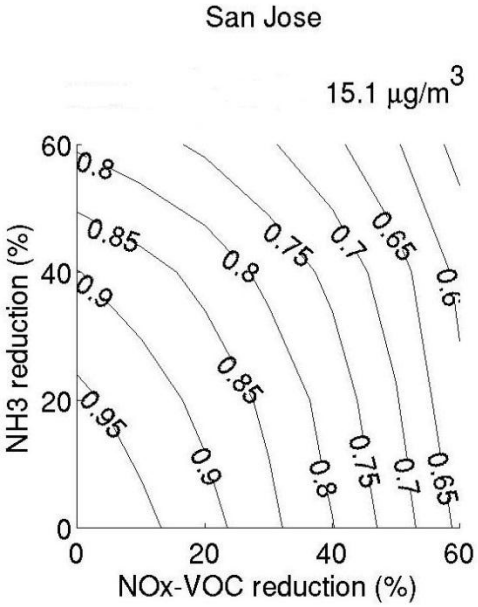
Avg. over four months (Dec-Jan, 2000-01 and 2006-07)

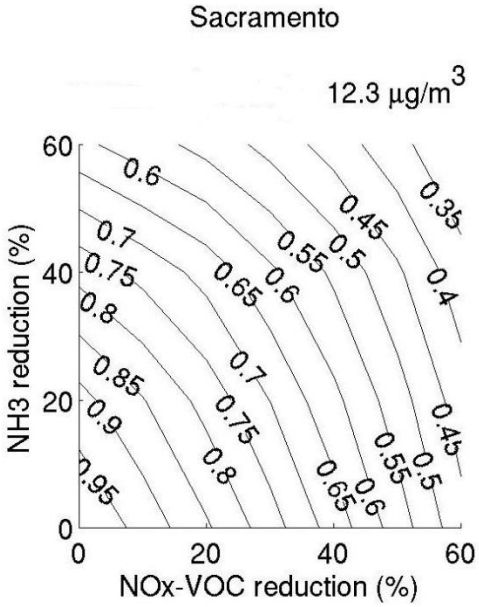


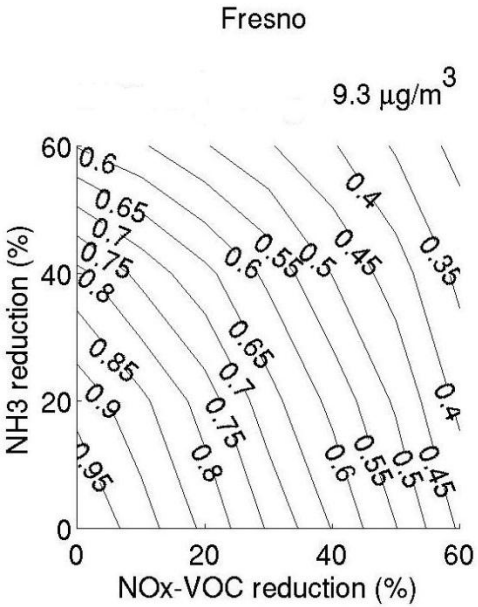
Soccer goal plots - avg. over 17 exceedance days (Dec-Jan, 2006-07)

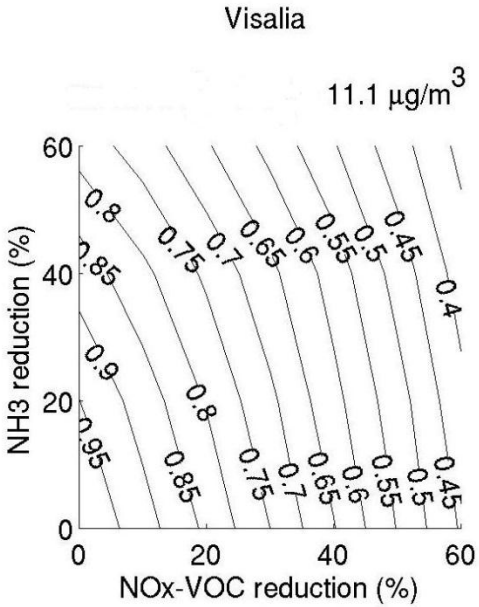


E=EC
O=OC
N=NO3
P=PM2.5



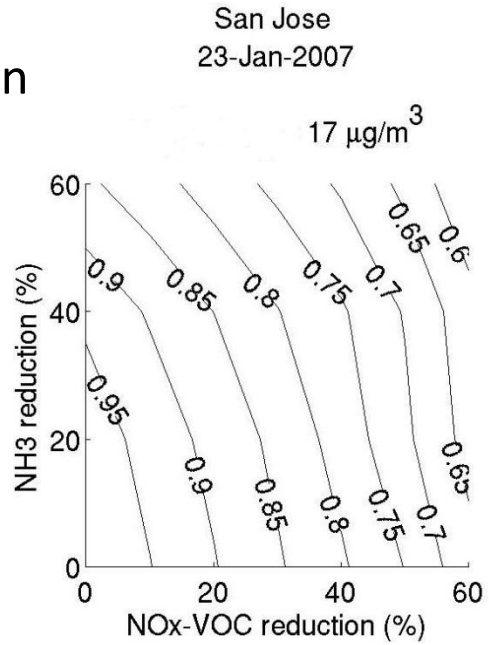


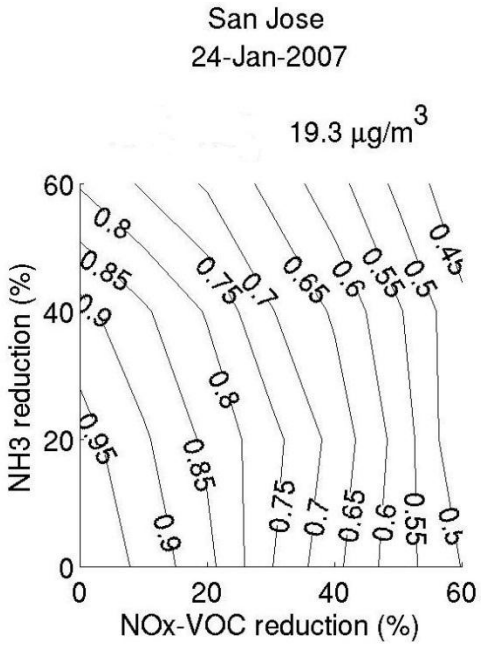


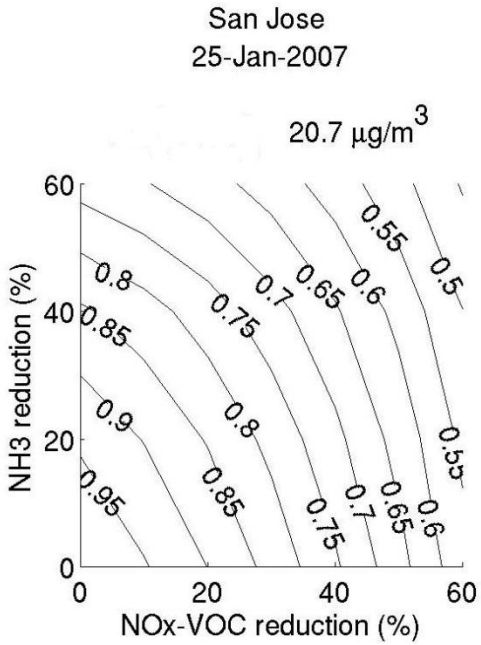


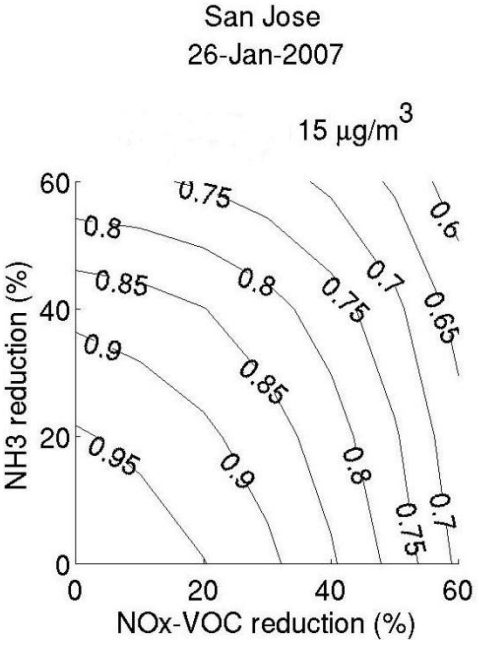
Avg. over 5 exceedance days

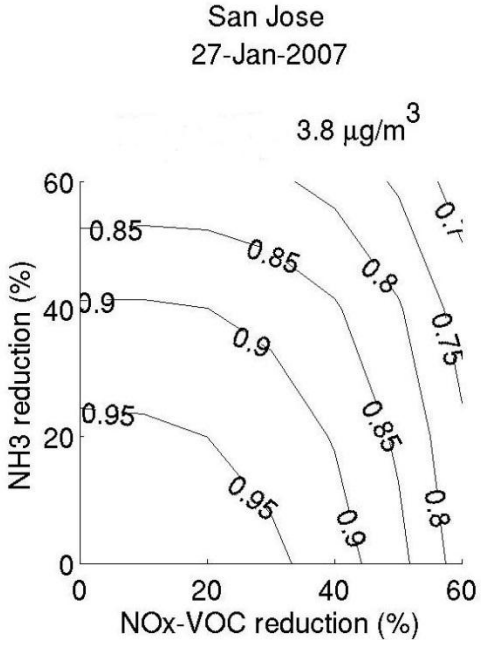
Time evolution

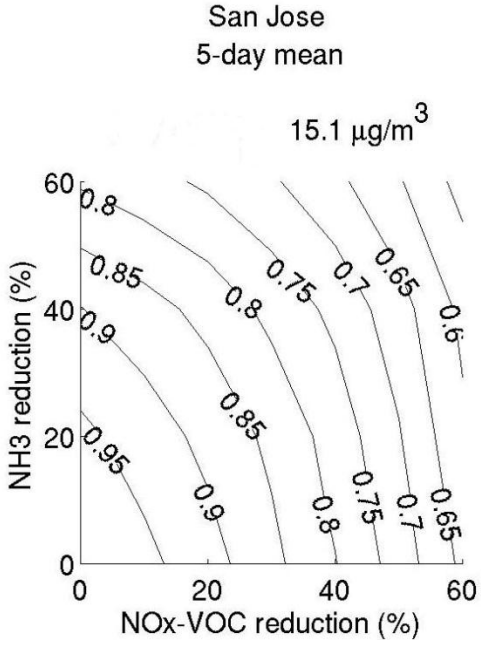








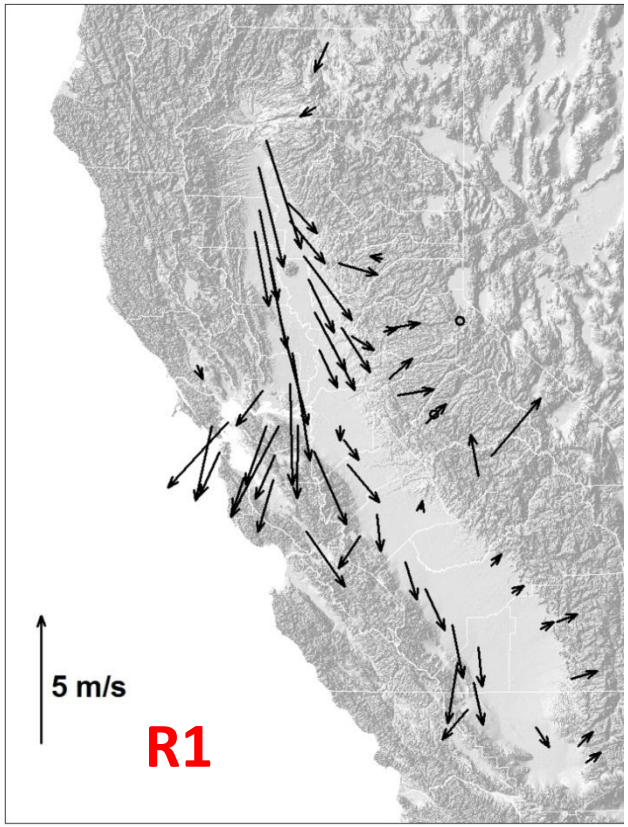


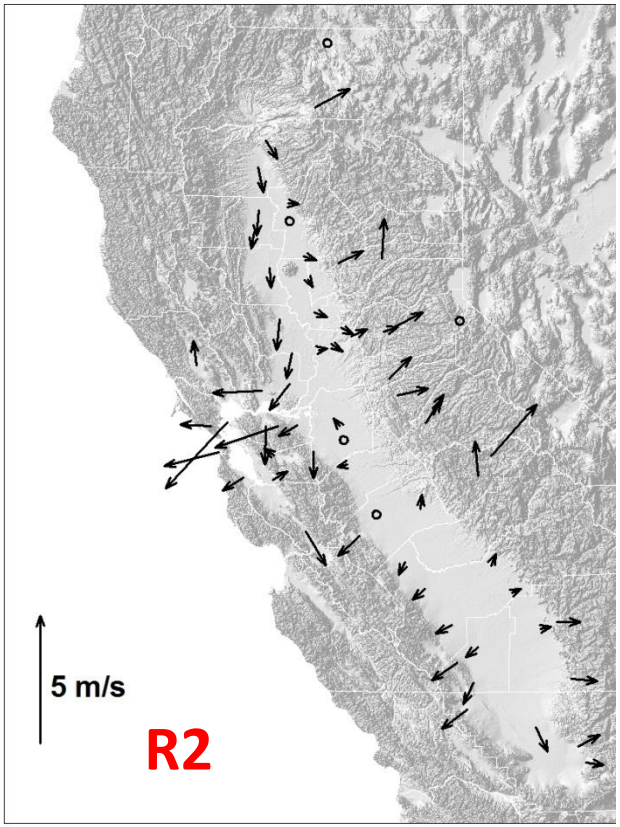


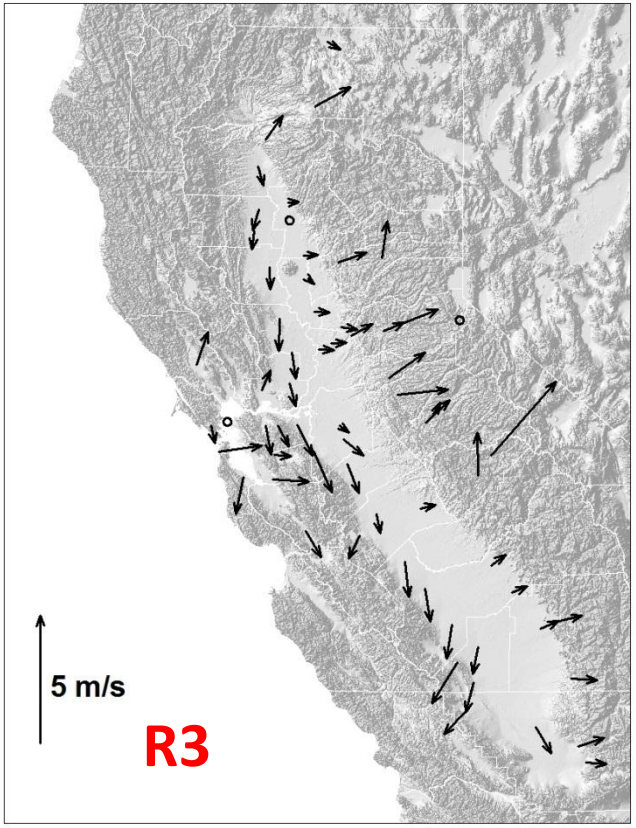
Issues

- AQMs generally underestimate PM2.5 in central California
  - They also underestimate ozone there
- The most severe underestimation is during peak episode days when attainment is demonstrated
- Is the problem due to emissions, meteorology or chemistry?
- This problem may exist elsewhere; not a unique central California problem
- Does this problem introduce uncertainty to model sensitivity?

Pattern-Based Model Evaluation





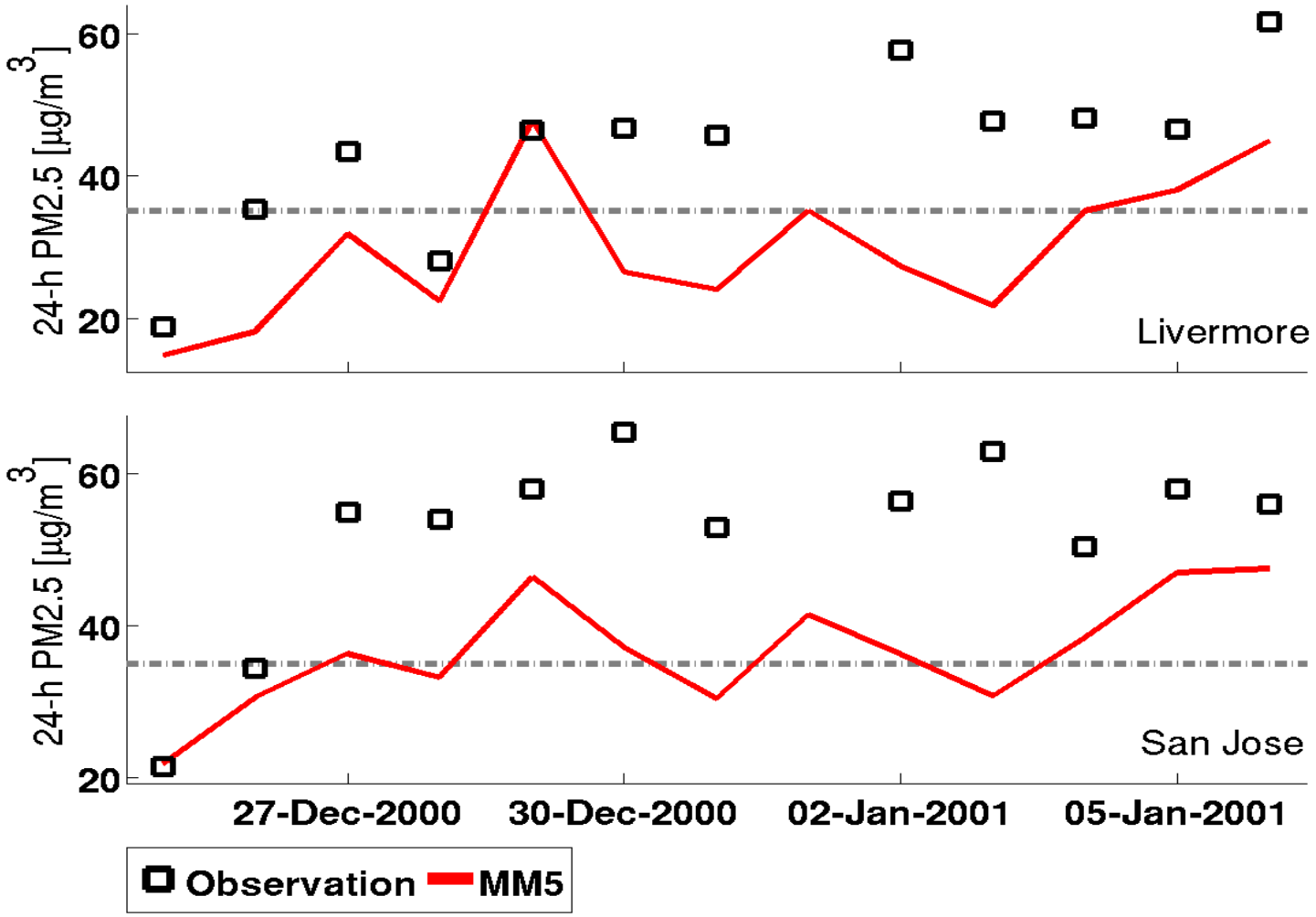


R1 → Elevated PM days, but rare Bay Area exceedances

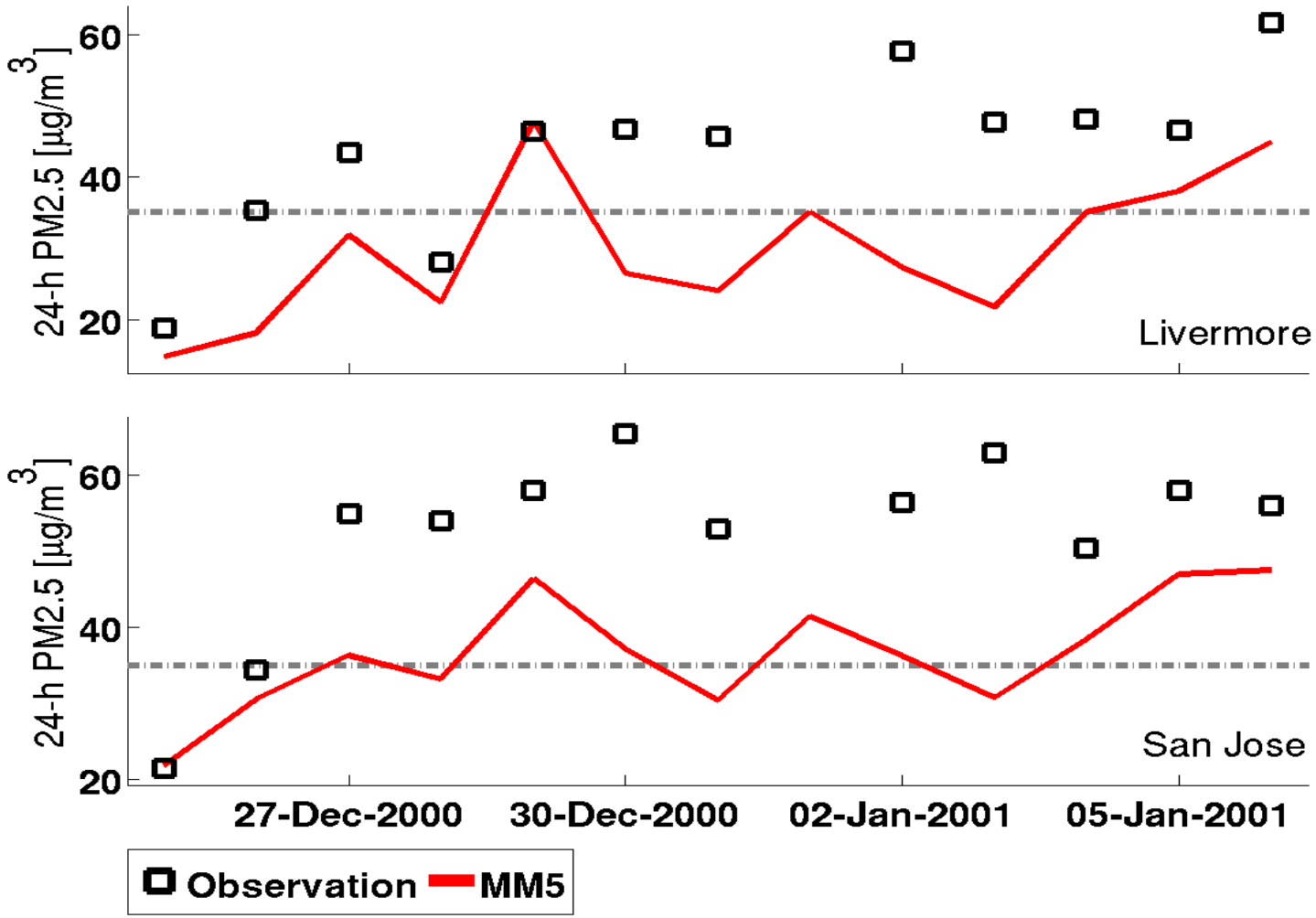
R2 → 80% of 24-h PM Bay Area exceedances

R3 → 14% of 24-h PM Bay Area exceedances

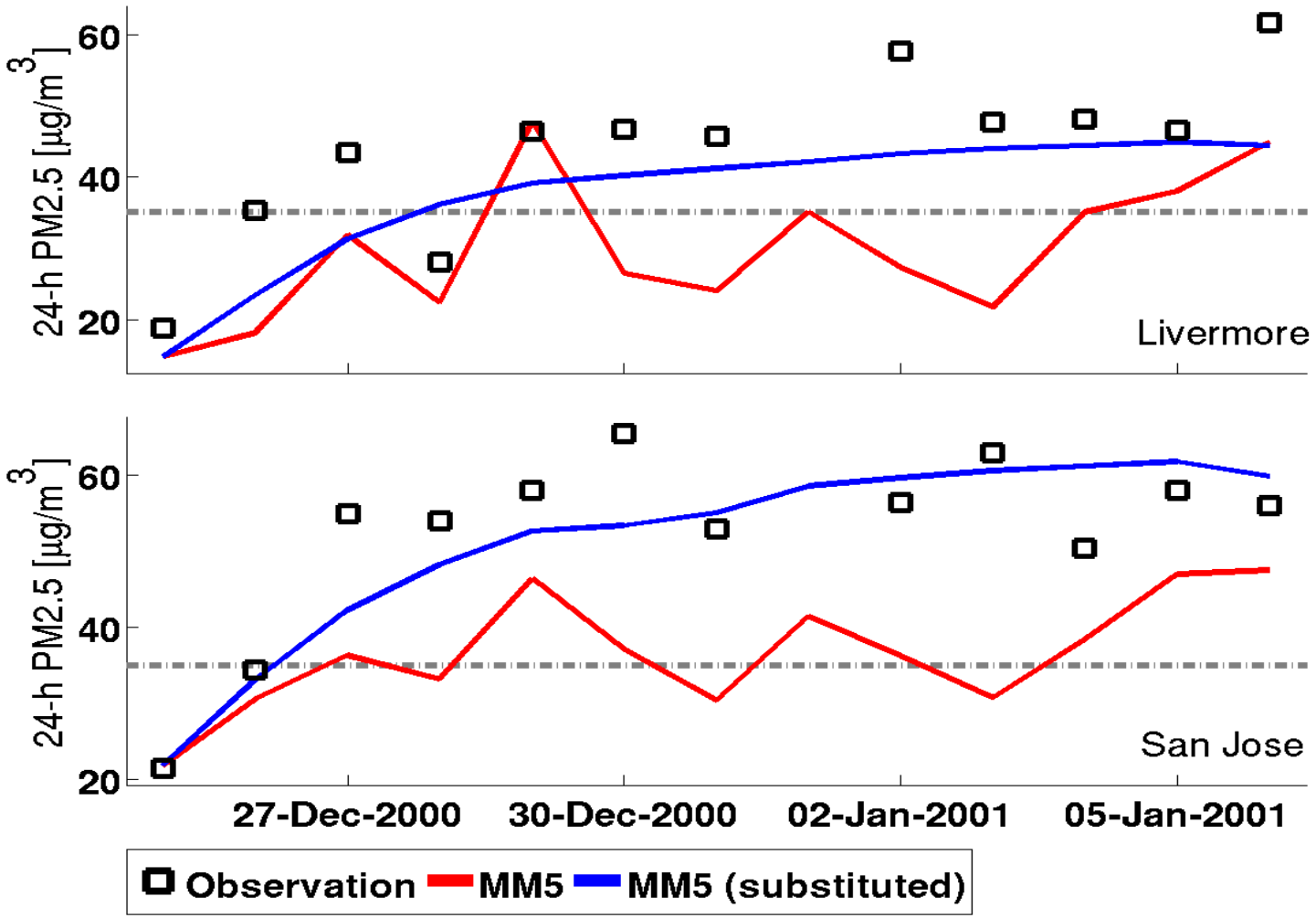
Example: CMAQ Performance for PM2.5



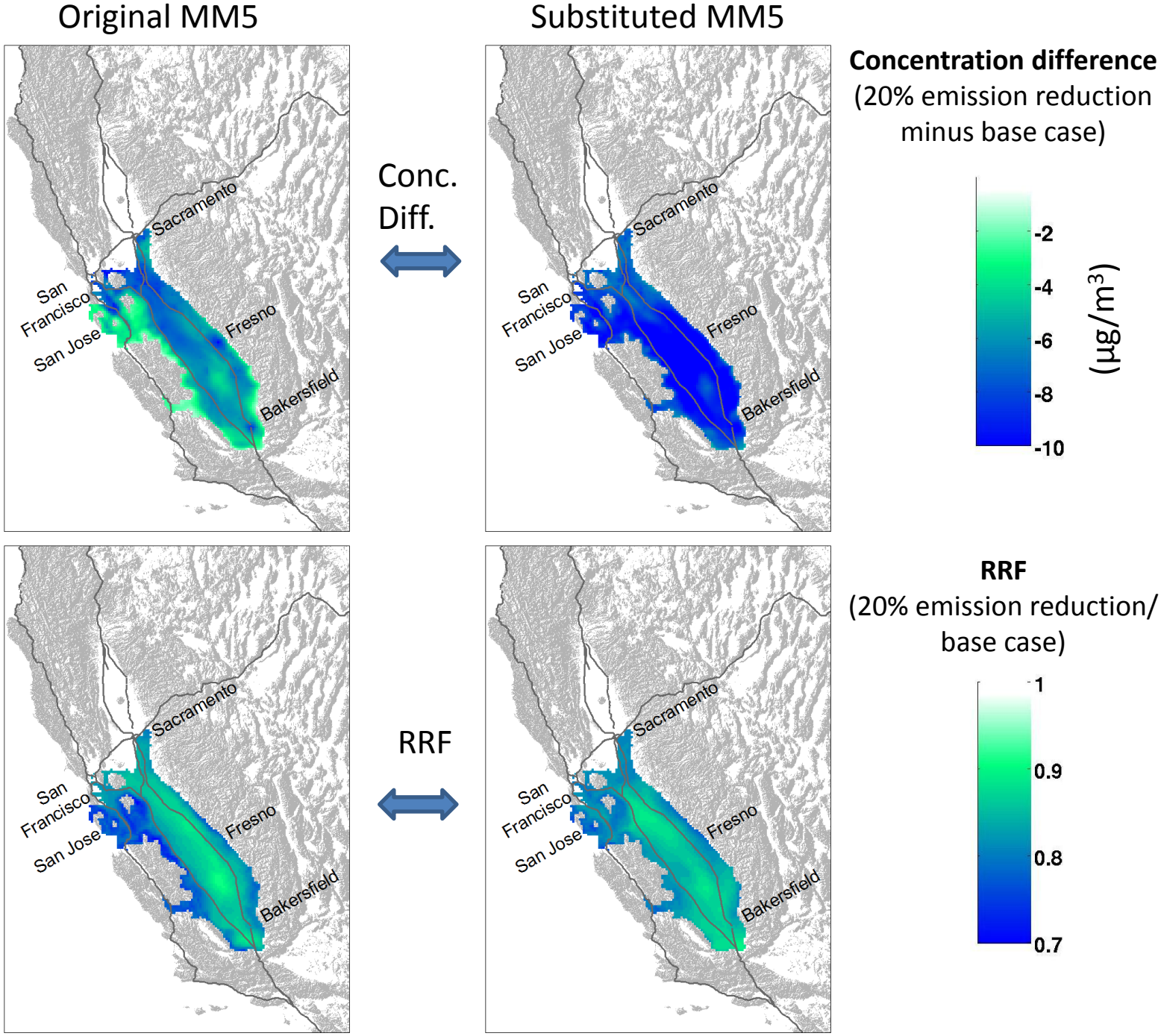
R1	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2
R1	R1	R1	R1	R*	R*	R1	R1	R1	R1	R*	R2	R+



R1	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2
R1	R1	R1	R1	R*	R*	R1	R1	R1	R1	R*	R2	R+
R1	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2	R2



Uncertainty Evaluation



Summary and Conclusion

- CMAQ simulates moderate winter PM2.5 levels accurately
- Model sensitivity to changes in emissions makes sense, but needs to be verified against observations
- CMAQ underestimates peak PM2.5 levels, mostly due to deficiencies in MM5
- WRF has similar symptoms
- Uncertainty in met models seems an inherent problem.
- Only air quality community simulates meteorology under high pressure conditions
- Most users are model applicants, not researchers
- Collaboration and leadership is much needed